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INCIDENCE OF MOUNTAIN PINE BEETLE ABANDONED GALLERIES IN LODGEPOLE PINE[1]

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ABSTRACT

Individual lodgepole pines have lower densities of attack by mountain pine beetles and a higher percentage of abandoned egg galleries in stands where beetle populations are low rather than high. Most trees contain some galleries having live beetles, as well as abandoned galleries. Females from galleries likely to be abandoned have been mated, discounting the unfertilized female as a reason for gallery abandonment. The amount and quality of blue-stain fungi carried by the beetle may influence success of gallery construction.

KEYWORDS: *Dendroctonus ponderosae, Pinus contorta*, egg gallery, pitch out

Mountain pine beetles (*Dendroctonus ponderosae* Hopkins) abandon many egg galleries after constructing only 1 to 2 inches on some lodgepole pine (*Pinus contorta* Douglas var. *latifolia* Engelmann) trees. This phenomenon was thought to be due to females not being fertilized (Amman 1975). In the study reported here, stands of lodgepole pine were surveyed and mountain pine beetle galleries examined to determine how common gallery abandonment is. A second objective was to determine incidence of fertilized females from galleries that have a high probability of being abandoned.

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METHODS

In September 1975, 3 to 6 weeks after the flight and attack period of the mountain pine beetle was completed, six stands of lodgepole pine on four National Forests--Bridger-Teton in northwestern Wyoming; Sawtooth in south-central Idaho; Targhee in southeastern Idaho; and Wasatch in northern Utah--were surveyed for trees infested by the beetle. A systematic random sample consisting of either 20 or 40 one-fourth acre (0.1 ha) plots was used where beetle populations were high [1.5 or more trees infested per acre (3.75/ha)] and a 100 percent cruise was used where populations were low [less than one tree infested per acre (2.5/ha)]. Attacked trees were tallied by diameter at breast height (d.b.h.), examined, and classed into three categories: (1) abandoned trees--greater than 50 percent of galleries abandoned or likely to be abandoned; (2) strip-attacked trees--a vertical strip of the trunk covered with galleries; and (3) mass-attacked trees--entire lower bole covered with galleries. Trees that were strip attacked and abandoned, or from which beetles were pitched out, were not killed whereas those that were mass attacked were killed.

In both 1975 and 1976, trees where large proportions of galleries were expected to be abandoned were examined. Abandoned galleries have characteristic whitish pitch tubes, an unobstructed opening to the gallery, and little or no fresh boring frass. Only the lower boles of the trees, where attacks can be found consistently, were examined. When few trees having pitch out or abandoned galleries occurred on the plots, additional off-plot trees were added to increase the sample size. Ten galleries were examined on the lower 6 feet (1.8 m) of the bole of each tree; however, fewer than 10 attacks occurred on some trees.

Data recorded from each gallery were: (1) length of gallery, (2) female present or absent, (3) male present or absent (4) eggs present or absent, and (5) beetles entangled in pitch within the gallery or in the pitch tube. When two beetles were in the same gallery, one was considered to be male. Where no male was found but eggs were present, the male was assumed to have left the gallery after fertilizing the female. This assumption seems reasonable because less than 2 percent of the females are fertilized prior to emergence and attack (McCambridge 1970). In addition, reemergence of females after completing an egg gallery is uncommon in the study areas.

In 1977, 20 females were removed from galleries likely to be abandoned. Sex of beetles was determined by criteria recommended by Lyon (1958). The spermathecae were removed, placed on glass slides, covered with cover slips, and crushed to release sperm. The presence or absence of sperm was determined by using a compound microscope (670 magnification). General observations of muscles and ovaries were noted.

RESULTS AND DISCUSSION

Abandoned trees.--Surveys of lodgepole pine stands showed that abandoned trees and those from which beetles were pitched out constituted 11 to 53 percent of the infested trees. Higher proportions of infested trees appear to be abandoned in plots having low beetle populations, for example on the Bridger and Sawtooth National Forests, than plots having high populations such as the Targhee and Cache (table 1). The Wasatch (high population) and the Teton (low population) did not fit this pattern well. The Wasatch had a fairly active infestation but the beetle population suffered heavy mortality during development due to drying of the trees, thus yeilding more females (71 percent) than males (29 percent) (unpublished data from life tables studies, Research Work Unit 2201, Intermountain Forest and Range Experiment Station, Ogden), a low population characteristic. The Teton had several large infested trees, consequently a sex ratio (60 percent ♀; 40 percent ♂) more typical of high populations was obtained.

Table 1.--*Types of mountain pine beetle infestations found in lodgepole pine trees in six study areas, 1975*

Plot	Area surveyed			Infested trees		Type of infestation		
				Per acre	Per hectare	Mass	Strip	Abandoned
	Acres	*Hectares*	*Percent*	*Number*		*Percent*		
Bridger	81	32.8	100	0.04	0.10	67	0	33
Cache	57	23.1	100	.74	1.83	79	0	21
Sawtooth	200	81.0	100	.05	.12	44	12	44
Targhee	5	2.0	3	20.40	50.04	63	26	11
Teton	68	27.5	100	.19	.47	85	0	15
Wasatch	10	4.0	6	1.50	3.71	40	7	53

The attack density was less on abandoned trees than on mass-attacked trees. For example, on the Targhee National Forest, Idaho, attacks averaged 2.5/ft^2 (30.4 cm^2) of bark surface (N = 50; SD = 0.72) on abandoned trees whereas an average of 9.6/ft^2 (30.4 cm^2) (N = 48; SD = 1.6) occurred on mass-attacked trees. The low attack density on abandoned trees suggests it as the reason for abandonment. The beetle attacks many more trees than their numbers are able to mass attack and kill. Most abandoned trees are smaller in diameter ($\bar{X}$= 9.3; SD = 2.3; N = 19) than mass-attacked trees ($\bar{X}$ = 11.4; SD = 2.6; N = 87). Large-diameter trees are more attractive than small ones even when the latter are baited with the beetles' aggregative pheromone (Rasmussen 1972).

Abandoned galleries.--Gallery abandonment was proportionately higher in small than in large diameter trees (fig. 1) as previously noted (Amman 1975). In trees classed as abandoned, females alone were found in 36.7 and 18.7 percent of the galleries for 1975 and 1976, respectively (table 2). Males and females were found together in only 6.7 and 8.3 percent of galleries for the 2 years. Gallery abandonment by females was high, accounting for 51.1 and 62.6 percent of the galleries for 1975 and 1976, respectively. In contrast, beetles found dead in the gallery or pitch tube accounted for only 5.5 and 10.4 percent of the galleries for the 2 years (table 2).

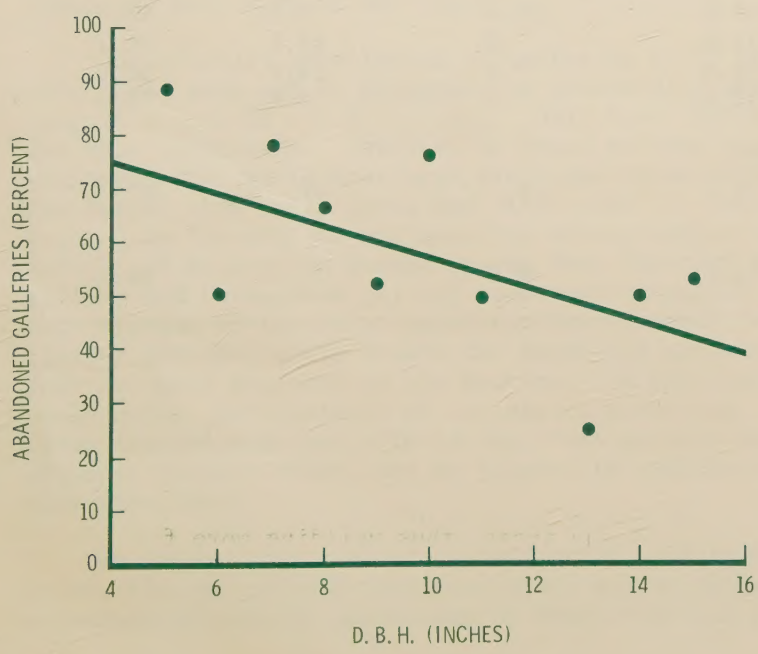

Figure 1.--Proportions of galleries in lodgepole pines of different diameter abandoned by mountain pine beetles.

The proportions of abandoned galleries were inversely related to the proportions of galleries that contained males ($R^2 = 0.44$; $P<0.05$). As the proportions of galleries that contained males increased, the proportions of galleries that contained eggs also tended to increase but was not quite significant ($0.10>P>0.05$). Galleries that contained females only were usually shorter than those containing both male and female (fig. 2), because the male helps to move boring frass and resin (when resin flow is heavy) down and out of the gallery.

Table 2.--*Mountain pine beetle galleries examined and classified according to presence, absence, or death of beetles*

Plot	Galleries examined	Female present	Female and male present	Female dead	Abandoned
	Number	- - - - - - - - - - - - *Percent* - - - - - - - - - -			
		1975			
Cache	24	41.7	8.3	16.7	33.3
Wasatch	63	31.8	9.5	7.9	50.8
Targhee	57	28.1	1.8	0.0	70.1
Sawtooth	9	100.0	0.0	.0	0.0
Teton	20	40.0	20.0	5.0	35.0
Bridger	7	42.9	.0	.0	57.1
Total in each class	180	*66*	*12*	*10*	*92*
Percent of total galleries	-	36.7	6.7	5.5	51.1
		1976			
Cache	56	17.9	19.6	7.1	55.4
Wasatch	21	19.0	.0	14.3	66.7
Targhee	51	25.5	7.8	15.7	51.0
Teton	65	13.8	.0	7.7	78.5
Total in each class	193	*36*	*16*	*20*	*121*
Percent of total galleries	-	18.7	8.3	10.4	62.6

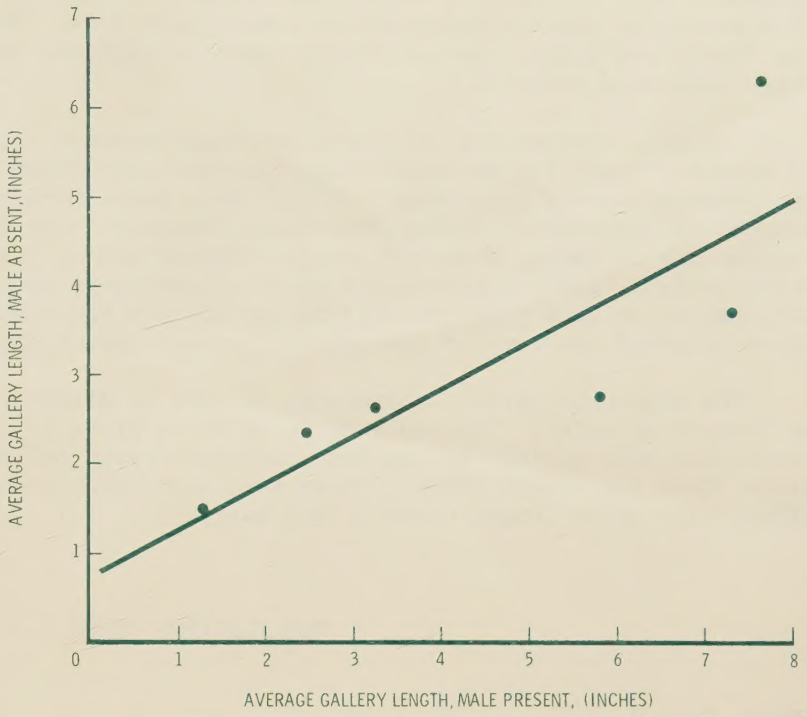

Figure 2.--Average lengths of mountain pine beetle galleries that contained males compared to those that did not contain males (only those plots used that had both categories represented).

Ten females were selected at random and dissected from the total of 20 that had been removed from galleries that showed signs of abandonment. All contained sperm and 6 of the 10 appeared to be of low quality. These females had air bubbles in the abdominal cavity, degenerate ovaries and wing muscles, and only a few visible oocytes. Therefore, lack of female fertilization (Amman 1975) is not a cause of abandoment. The apparent low vigor of some beetles may be one factor for lack of successful gallery establishment and subsequent abandonment. Adults found dead in the galleries or pitch tubes may have been of low vigor.

Successfully established galleries up to 12 inches long ($\overline{X}$= 5.5; SD = 3.4; N = 16) were found adjacent to abandoned or potentially abandoned galleries only 1 to 2 inches long ($\overline{X}$ = 1.9; SD = 0.9; N = 16). Only trees having both types of galleries were used for this comparison. However, no brood matured regardless of gallery length because of resinosus that kills most eggs (Reid and Gates 1970) and prevents development of the few larvae that hatch (Reid and others 1967). Successful gallery construction may be related to the quality and quantity of microorganisms carried by the beetles. Inoculations of blue-stain fungal spores into the tree by the beetle when it starts the gallery and throughout gallery construction causes rapid drying of the wood and bark tissues as the fungi penetrate the sapwood (Reid 1961). Without the fungi, the tissues probably would remain too moist for optimum brood development even in trees that are mass attacked by the beetles. In addition, greater resin flow per attack would occur, particularly at low-attack densities. Therefore, the differences between those females that are able to construct gallery and those that cannot, even though adjacent to each other, may be related to quality and quantity of blue-stain fungi that they carry.

An interesting account of blue-stain quality was given by Rumbold (1941). She wrote, "It was noticed that when there was an epidemic of *Dendroctonus monticolae* (synonymized with *D. ponderosae* by Wood 1963) and *D. ponderosae* in the forest, the

specimens sent in, whether insects or the bark or sapwood of infested pines, developed *Ceratastomella montium* and yeast in almost pure form. When the beetle infestation in the forest was light, however, the *C. montium* cultures isolated grew slowly and other fungi also were isolated."

Visually the quality of blue-stain fungi appears to be related to size or vigor of tree infested, for in small trees--particularly those of poor vigor--blue stain development appears poor (Amman 1976). This seems more noticeable toward the latter part of an infestation, after most large-diameter trees have been killed and the beetles are infesting primarily small-diameter trees. Small trees dry excessively, which probably affects blue-stain survival and spore production. Pupal chambers of the beetles in such trees usually do not contain the abundant fungal fruiting bodies found in pupal chambers of the moister large-diameter trees.

The abandoned gallery phenomenon may not be directly associated with the presence or absence of males. The low numbers of males probably are indictive of poor brood conditions such as thin phloem and excessive drying encountered, particularly in small trees (Cole and others 1976). These same conditions also could be expected to adversely affect blue-stain fungal quantity and quality.

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